

Form NP: NEW PROGRAM PROPOSAL FORM

Sponsoring Institution(s): Missouri University of Science and Technology

Program Title: Explosives Engineering

Degree/Certificate: Master of Science

Options: N/A

CIP Classification: 14.2101

Implementation Date: ASAP

Cooperative Partners: N/A

Expected Date of First Graduation: May 2010

AUTHORIZATION

Steve Graham

Senior Associate Vice President for Academic Affairs

Name/Title of Institutional Officer	Signature	Date
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INTRODUCTION

Explosives engineering can be described as the application of explosives in scientific and engineering endeavors, and the science and technology of explosives, including their formulation, physics, effects and use. The United States is the largest consumer of explosives in the world, with US civilian sales estimated at 3.15 million metric tons in 2007.¹ This is principally because the United States also has the largest mining industry in the world. 85.5% of explosives consumption is in the mining industry, with 66.3% of total consumption used in coal mining to remove rock from above coal seams, principally in the western United States (coal mined using explosives is responsible for over 30% of US electrical power generation). Of the

¹ Figures from USGS 2007 Minerals Yearbook - Explosives

remaining 14.5% of consumption, 11.6% is used in civil excavation for highway road cuts, tunnels, leveling ground for commercial structures, basements, trenches for utilities, etc. Non-mining and construction consumption accounts for the remaining 2.9%. The largest state consumer is Wyoming with 638,000 metric tons, followed closely by West Virginia at 489,000 metric tons and Kentucky with 368,000 metric tons. Missouri ranks as number 14 in the nation in explosives consumption at 50,500 metric tons. This is principally because of crushed stone production, where Missouri ranks number four in production in the nation at 81.3 million metric tons, and lead mining, where Missouri is the number one producer in the nation (over half of the vehicle batteries in the US come from Missouri lead).

The history of explosives at Missouri S&T goes back to its inception as the Missouri School of Mines (MSM). The use of explosives since the invention of dynamite by Alfred Nobel (of Nobel Prize fame) has been a fundamental cornerstone of the mining and civil excavation industries for the excavation of rock. Over the years, MSM/University of Missouri-Rolla/Missouri S&T has been one of the principal universities both in teaching explosives engineering and performing explosives research. Over the last decade it has emerged as the number one university for explosives engineering at the undergraduate level in the nation. This is based on the following facts:² in 1997, it was the first to have an undergraduate explosives engineering emphasis, followed in 2005 by an explosives minor for both undergraduate and graduate degrees, and in 2007 by an explosives certificate. A master's degree in explosives engineering is the natural progression. In addition, the university has provided the most PhD graduates in explosives engineering research that have gone onto university careers.

The emphasis on explosives education has increased enrollment in the mining engineering program, resulting in more than a doubling of the department enrollment (from 77 in FS 2004 to a projected 190 in FS 2009)³. The advertisement of the teaching of explosives classes has gained national attention, with TV coverage on The Learning Channel, the Discovery Channel, and the National Geographic Channel and even international coverage with the Canadian Discovery Channel, with programs aired throughout the world. More recently the summer explosives camp has gained national attention, published on the front page of the New York Times Science Times and in the International Herald Tribune, and airing on National Public Radio. This camp is for high school students, 16 years and older and the first camp student graduated with a mining engineering degree with an explosives engineering minor in May 2009 from the first pilot camp of three attendees in 2004. The camp has now grown to three camps of 20 students per year held in June and this is viewed as a major future source of students for the proposed program.

Since the fall of 2005 through the spring of 2009, a period of only four years, there have been six undergraduate explosives certificates and two graduate explosives certificates, 28 undergraduate minors and two graduate minors conferred. This represents an average of 8 minors or certificates conferred per year. In the fall of 2009, there were 26 students enrolled for minors in explosives engineering and seven students are ready to enroll for the master's, degree, two of whom were undergraduate mining engineering majors at Missouri S&T.

² Statistics are given in Appendix A.

³ See mining engineering program enrollment statistics in Appendix A.

This will be the first program in North America in Explosives Engineering, and because of this, there are no statistics on the employment of explosives engineers. However, out of the 30 explosives engineering minor and 8 certificate recipients to date, we have data (shown in Appendix A) tracking most of these graduates that verifies they were able to obtain good paying jobs (only five were non-mining students). The U.S. Department of Labor shows 5,333 explosives workers and 7,070 mining and geological engineers were employed in 2006, although these numbers appear to be conservative estimates.⁴ We also have letters supporting the need for an advanced degree in explosives engineering from industry, our alumni, industry associations and prospective students wishing to obtain an explosives engineering degree (see Appendix G).

Overview of Market Analysis and Program Need

A market analysis revealed a strong need for, and interest in, the M.S. in explosives engineering program. Prospective employers are enthusiastic about the program and view it as a valuable opportunity to meet a critical need for experts capable of working with increasingly complex explosives technology and to replace an aging workforce. Current and prospective students have expressed a strong interest in explosives technology and the desire for a specialized degree in explosives engineering. In addition, letters of support from mining industry professional associations and alumni document the need for the program.

The demand for the degree is evident in the number of students choosing to obtain certificates and minors in explosives engineering. From the fall of 2005 through the spring of 2009, there have been six undergraduate certificates and two graduate certificates, 28 undergraduate minors and two graduate minors conferred in explosives engineering. In the fall of 2009, there were 26 students enrolled for minors in explosives engineering and seven students are ready to enroll for the master's, degree, two of whom were undergraduate mining engineering majors at Missouri S&T.

Market and enrollment analyses established the financial viability of the program, and indicate that the program will be viable with student enrollment numbers much less than those predicted by student surveys and employer demand for graduates. In a poll of 200 current undergraduate and graduate students, 31 responded positively regarding their intent to enroll in the program; an additional 11 graduating seniors have indicated they will enroll in the explosives engineering M.S. program. The three one-week explosives camps that fill each summer with high school students eager to learn more about explosives technology are a proven pipeline into Missouri S&T, with a significant percentage of these students planning to continue their studies in explosives.

In addition to the information solicited for the proposal, the need for graduates with expertise in explosives engineering has been expressed in mainstream media sources such as the New York Times, National Public Radio, the Learning Channel and the Discovery Channel. These

⁴ For example, the National Mining Association estimates that approximately 5,000 mining engineers will be retiring in the next decade and there are 3,000 U.S. International Society of Explosives Engineers (ISEE) members, which is not close to half of the explosives engineers (according to the Assistant to the ISEE Executive Director).

discussions have focused on societal need and the aging workforce in this industrial sector, and acknowledge the resident expertise at Missouri S&T in this technical field.

Detailed market and need analyses are presented in subsequent sections of the proposal. A brief summary is provided here to highlight the thoroughness of the analysis and to demonstrate the broad support for the program among students, faculty, alumni and industry.

Student Enrollment Projections (Section 5 – Form SE)

A total of 81 students are predicted to enroll in the program within the first five years. These predictions are based on current enrollments in Missouri S&T certificate and minor programs in explosives. The proposed M.S. program will thus meet existing demand with current students. Five graduate students are prepared to immediately enroll in this program as soon as it becomes available.

Program Characteristics and Performance Goals (Section 8 – Form PG)

This section highlights the high demand for graduates with the M.S. in Explosives Engineering degree and the predicted placement rates.

CBHE Clarifying Comments (Section 9 – Form CC)

In subsection B, the strong current and prospective student interest is discussed as well as specific examples of the industry and societal need to increase the credentials of the explosives engineering workforce. In addition, this section discusses training and certification options in explosive engineering that will exist for enlisted soldiers at Fort Leonard Wood, as strong ties are already in place between the university and the army base.

Criteria by the President (Section 10 – Form CP)

Industrial market analysis data and survey results from current mining engineering students are summarized. Subsection B contains detailed information on the effective student recruitment programs already in place, such as the extremely popular summer explosives camps. Retention efforts to ensure the success of the program are also discussed.

Employment, Graduation, and Enrollment Statistics (Appendix A)

The employment history of Missouri S&T students who have graduated with expertise in explosives engineering demonstrates the demand for graduates in industry and the government sector. This section shows trend data for enrollment in the area of explosives and demonstrates that enrollment targets appear achievable.

Recent Poll of Students (July 2009) (Appendix B)

A poll of 200 current undergraduate and graduate students, described in this section, resulted in 31 students positively responded regarding their intent to enroll in the program with an additional 11 graduating seniors indicating that they will enroll in the explosives engineering M.S. program.

Letters of Support (Appendix G)

To further illustrate the strong support for the program, quotes from industry associations, industries, and students are provided in the following section. The source of these quotes and additional support letters appear in Appendix G.

Support from Mining and Explosives Associations

- “The number of graduates of engineering schools with training in explosives cannot keep up with the demand in the mining industry, the leading employer of explosives engineers, and the current population of engineers in the field is aging toward retirement.” – The National Mining Association.
- “The explosives industry has experienced rapid change in applied technology in recent years ... Well-trained explosives professionals that can effectively communicate with citizens and local officials have become an absolute necessity. I’m certain that the Missouri S&T graduates with advanced knowledge of explosives will be put to work as quickly as they become available.” – Steve Rudloff, Missouri Limestone Producers Association.
- “We believe that an M.S. program in Explosives Engineering will help the industry meet its personnel needs.” – Lon Santis, Manager of Technical Services, Institute of Makers of Explosives.
- “We have worked to encourage young people to enter our industry with an eye on the deficit of workers coming soon because of our aging workforce ... We have a problem in our industry... we ask you to continue that industry education support by approving the Master of Science degree in Explosives.” – Jeffrey L. Dean, Executive Director, the International Society of Explosives Engineers.

Support from Prospective Employers

- “Using current market demand and projecting forward for ten years, approximately twelve master level Explosives Engineers would be able to find employment with explosive manufacturers.” – Mitchell D. Lee, Vice President, Orica USA.
- “In speaking with Dr. Paul Worsey recently, he had conveyed to me that the MS&T Mining Department is seeking to develop an accredited Masters Program in Explosives Engineering. I feel this would be a very good step forward for the Explosives Industry, as well as for the University.” – Kurt B. Oakes, General Manager, Olson Explosives, Inc.
- “As an R&D company that deals primarily in the development, characterization, and safety testing of energetic materials, the lack of qualified personnel with explosives education and experience can be seen in all walks of industry ...” – Gary Eck, Vice President of Research and Laboratory Manager, UTEC Corporation.
- “There is a need for professionals with advanced education and training to develop and implement advancements in the development and usage of explosives materials.” – David Obergefell, Vice President, Manufacturing –International, US Gypsum Company.

Demand from Students

- “MS&T is leading the nation in areas of industrial interest as well as reputation. Employers know that when an MS&T graduate is hired, that employee will be properly trained and experienced in all engineering aspects. The school now has a chance to optimize an economic situation by introducing a desired and well-implemented explosives engineering program.” – Buck Hawkins, Mining Engineering Undergraduate.

- “I was struck by the enthusiasm of the faculty and the extent of the coursework relating to explosives and pyrotechnics, and after further research, found it to be the only school offering this kind of coursework ... I believe that the creation of an explosives engineering M.S. and my subsequent degree in it will open doors in industry and research that another degree would not ...” – Alexander Tyson, Missouri S&T Undergraduate.
- “With the addition of the Masters of Explosives Engineering, I know that the school will have one more reason to advertise itself apart other institutions and draw additional students from more diverse areas of the U.S. and world ...” – Nathan Rouse, Missouri S&T Graduate student.

Form SE: STUDENT ENROLLMENT PROJECTIONS

Table SE-1 contains the expected enrollment forecasts from year one (2009-10) to year five (2013-14) originally forecasted in fall 2008. These projections are based on our experience with the mining engineering M.E. program and on exploratory discussions with students currently enrolled and include projected students from external advertisement of the program once approved. To ensure financial viability we have still decided to use what we consider to be a conservative estimate. The results of a more recent poll of students are appended in Appendix B. This poll indicates that our projections are overly conservative for years one and two.

Table SE-1: Expected Enrollment Potential from Year 1 through Year 5 -Conservative Estimate

Year (A/C)	1 (09-10)	2 (10-11)	3 (11-12)	4 (12-13)	5 (13-14)
Full-time	5*	6	8	10	12
Part-time	-	5	8	12	15
Total	5	11	16	22	27

** We already have five students enrolled in graduate programs studying explosives engineering who are waiting to transfer to this program as soon as it becomes available. They are being housed currently in the mining M.S. program on a temporary basis with obtaining a mining M.S. with a minor in explosives engineering only as a fallback. Our only major enrollment concern is being swamped and we may have to be selective to restrict enrollment to a manageable level.*

It has been suggested that mining M.S. enrollment will decrease as the explosives M.S. increases. However, this will not be the case, as department statistics show that, in the last ten years, there have only been ten M.S. in mining engineering degrees conferred (none within the last three years). The department’s statistics show that 40% of MS in mining engineering students go on to earn Ph.D.s (four of the 17 Ph.D.s awarded in the same period). Therefore, it is expected that a similar percentage of the M.S. in explosives engineering students will go on to do Ph.D.s in mining engineering or other fields at S&T. M.S. programs are an important recruiting tool for Ph.D. programs. Four of the 17 Ph.D.s in mining engineering in the last ten years had explosives-related dissertations and two of these were graduates who earned M.S. in mining engineering degrees. Of these four, three became assistant professors in US universities,

teaching explosives classes and performing explosives-related research. The fourth went to a defense contractor and is overseeing explosives-related projects.

Table SE-2: Enrollment at end of Year 5 for the program to be financially and academically viable

YEAR	5
FULL-TIME	9
PART-TIME	9
TOTAL	18

Form PS: PROGRAM STRUCTURE

A. Total Credits Required for Graduation: 30 hours

The proposed M.S. degree in explosives engineering will meet or exceed requirements listed in the Missouri S&T Graduate Catalog. The program structure will vary according to the interests of candidates for the degree. All candidates will pursue a plan of study that emphasizes the preparation of a thesis in explosives engineering.

B. Residency Requirements:

Research work normally must be performed on the Missouri S&T campus. Exceptions may be made for persons working at government facilities, national labs, explosives industry private companies and private research facilities where comparable or superior facilities are available. In such cases, S&T will retain the academic supervision of this work.

C. General Education: Not Applicable

D. Major Requirements: Total Credit Hours = 30

With guidance from their advisor and graduate committee, each candidate will complete a plan of study to satisfy the interests of the candidate and their advisor, plus requirements for the Master of Science degree, as described in the Missouri S&T Graduate Catalog:

Master's Degree with Thesis – minimum of 30 hours graduate credit; at least six hours to be 400-level courses; no more than six hours of 200-level courses; six hours minimum devoted to graduate research, ExpE 490; no more than 12 hours of research, special readings and seminar.

As part of this proposed M.S. degree program, candidates will complete four courses from a list of core courses. (The list of core courses will be reviewed and updated based on the availability of existing and new courses as they are developed.) If a student has already taken classes from this list as an undergraduate student (e.g., MinEng 307 which is a required mining class), other explosives engineering classes may be substituted.

The core classes are:

- | | |
|-----------------------|--|
| (3) ExpEng/MinEng 307 | Principles of Explosives Engineering |
| (3) ExpEng/MinEng 350 | Blasting Design and Technology |
| (3) ExpEng 351 | Demolition of Buildings and Structures |

- | | |
|----------------|--|
| (3) MinEng 383 | Tunneling & Underground Construction Techniques |
| (3) ExpEng 402 | Environmental Controls for Blasting |
| (3) ExpEng 406 | Scientific Instrumentation for Explosives Testing and Blasting |

In addition, candidates will select two or more courses from the core classes or the following elective Explosives Engineering courses⁵ (Exp Eng course descriptions are included in Appendix E with the proposed Graduate Catalog description):

- | | |
|-----------------------|--|
| (3) ExpEng 309 | Commercial Pyrotechnics Operations |
| (3) ExpEng 313 | Stage Pyrotechnics and Special Effects |
| (3) ExpEng 305 | Explosives Handling and Safety |
| (0-3)ExpEng 491 | Internship |
| (3) ExpEng 401 | Blast Mitigation |
| (3) ExpEng/MinEng 407 | Theory of High Explosives |

Out-of-department courses may also be taken as elective courses according to a candidate's special interests. Suggested out-of-department elective courses are listed below.

For those with an interest in rock blasting:

- | | |
|----------------|--|
| (4) Geo 220 | Structural Geology |
| (3) Geo 301 | Advanced Structural Geology (currently experimental) |
| (3) GeoEng 371 | Rock Engineering |

For those with an interest in demolition or blast protection:

- | | |
|---------------|----------------------------|
| (3) CvEng 217 | Structural Analysis I |
| (3) CvEng 320 | Structural Analysis II |
| (3) CvEng 223 | Reinforced Concrete Design |

For those with an interest in weapons systems design:

- | | |
|---------------|---------------------------------|
| (3) McEng 336 | Fracture Mechanics |
| (3) AeEng 251 | Aerospace Structures I |
| (3) McEng 320 | Advanced Mechanics of Materials |

These classes are all currently listed in the S&T catalog. The list of elective courses will be reviewed and updated based on the availability of existing and new courses as they are developed. If a student has already taken classes from this list as an undergraduate student (e.g., MinEng 307 which is a required mining engineering class), other engineering classes may be substituted.

Free Electives

Twelve hours of core courses, six hours of program-specific courses and six hours of research are required, leaving six hours to be selected by candidates in consultation with their advisor

⁵ Currently ExpEng designation does not exist and was formulated by the S&T registrar. It will be implemented when the MS is approved. The courses are currently designated with the same MinEng number. All of these courses are currently taught, with the exception of 491 Internship and 401 Blast Mitigation, which will be added.

from the other core courses, other explosives engineering elective courses or out-of-department courses. The 12 hours of core courses, six hours of program specific courses, 6 hours of research and six hours of elective courses add up to the 30 required hours.

Requirements for Thesis, Internship or Other Capstone Experiences:

All candidates will write and defend a thesis at the conclusion of their course work. An internship is recommended but not required. For those candidates without work experience in an explosives-related industry, an internship will be strongly encouraged.

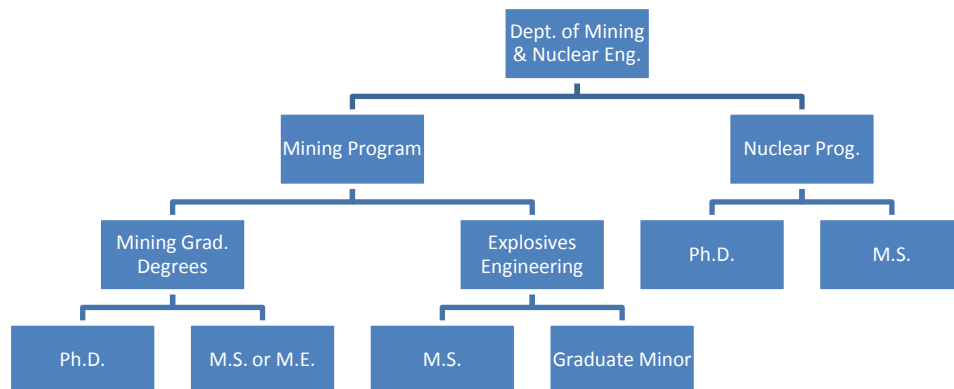
Unique Features

The main unique feature of the explosives engineering master's program is that it is the only program of its kind in the Americas. The most similar graduate program is a master's in engineering mechanics with a specialty in explosives engineering (12 hours of explosives-related coursework) at New Mexico Tech. Missouri S&T already exceeds New Mexico Tech's offering with the S&T graduate minor (15 credit hours, details can be found in the S&T Graduate Catalog on line) in explosives engineering, available since 2005.

Form FP: FINANCIAL PROJECTIONS – (deleted)

Administrative Structure

The MS degree will be an integral part of the Department of Mining and Nuclear Engineering at Missouri S&T and the students will be counted as mining engineering program graduate students. The strengths of both mining and explosives engineering are augmented using this symbiotic relationship.



Facilities and Space Needs

Current facilities will accommodate the explosives engineering graduate students. These facilities include modern lecture facilities at McNutt Hall equipped with an instructor station (which includes a computer, VCR and a ceiling-mounted LCD projector) linked to the campus network through a high-speed data network, the Missouri S&T experimental mine and the energetic materials research facility.

- *Underground Mine Facility:* The Missouri S&T Experimental Mine is one of only a few such facilities available on a university campus for mining engineering education. The facility is used primarily by the students and faculty of Missouri S&T for instruction and research in mining and geological engineering practices. The Experimental Mine is located on Bridge School Road, just west of Rolla, 1-1/2 miles from the Missouri S&T Campus. It consists of two underground mines, two small quarries, explosives magazines, a classroom and office facility, a shop building, and a garage on a 19-acre site. The underground mine facility is already extensively used for explosives classes and research.
- *Surface Quarry Facility:* The Missouri S&T Experimental Mine also includes two small surface quarries used for teaching and research by mining engineering faculty and students. These quarries are already extensively used for explosives classes, research, demonstrations and of course explosives camp. The facility is also being used for the filming of “The Detonators” a Discovery channel series on explosive demolition that aired in the first half of 2009.
- *Energetic Materials Research Facility:* The Energetic Materials Research Facility (Explosives Research Lab) laboratory is housed in a converted former U.S. Bureau of Mines research foundry (Building 4) adjacent to the new entrance to the Missouri S&T campus. The laboratory contains two blasting chambers (rated for 1 kg and 4 kg of explosives, respectively), a shop, a computing workstation running Autodyne 3D© software (an industry standard for performing closely-coupled computational fluid dynamics/computational structural dynamics calculations), high-speed film (up to 1.25 M frames per second) and video cameras (up to 90k frames per second), gated ICCD camera (up to 55 nsec exposure), flash x-ray system, 16-channel digital data acquisition system, three high-energy pulzers, two delay generators, two initiation systems for exploding bridgewire detonators, and explosive magazines. The laboratory is currently used for teaching MinEng 301, 350, 390, 406 and 490. The facility was recently extended using funding from the Chancellor to house the new 11 ft diameter large scale blast chamber acquired from the Army Chemical Demilitarization Command in Tooele, Utah. This chamber is 84 tons and represents a major upgrade to the facility, raising the facility to the realm of world-class capabilities.
- *Facilities at Operating Mines and Quarries:* Field trips to operating mines have been used intensively to demonstrate real-world mining facilities, especially for rock blasting, the major use of explosives. In the past, many explosive research projects have involved industry participation for both funded faculty, undergraduate and graduate research. It is expected that these links will continue.

During the academic year 2007-2008, nine explosives engineering courses were taught at Missouri S&T (MinEng 307, MinEng 309, MinEng 313, MinEng 350, MinEng 351, MinEng 383, MinEng 402, MinEng 406, and MinEng 407) and the facilities can easily accommodate the extra courses anticipated for the MS program. MinEng 383 and MinEng 402 were taught distance only and MinEng 307 and MinEng 350 were taught distance concurrently with the on-campus classes. The mining engineering program has two tower DVD bulk copiers to facilitate the distribution of course DVDs for distance courses.

The current facilities can accommodate the explosives engineering courses, the main need for the master's program being extra personnel and graduate student assistance.

Form PG: PROGRAM CHARACTERISTICS AND PERFORMANCE GOALS

Student Preparation:

- Students will be required to meet the standard graduate school admission requirements for the Missouri University of Science and Technology.

Faculty Characteristics:

- *Any special requirements (degree status, training etc.) for assignment of teaching for this degree program?* This program will be supported with a combination of existing Missouri S&T regular faculty and adjunct industry instructors who bring specialized and practical experience to the courses they will teach. In the future, faculty from other academic institutions may teach additional courses. This would leverage what we have and allow us to provide more complete and varied course offerings. These academic faculty are expected to hold a PhD or its equivalent in their area of specialty.

Faculty involved in the program are based around existing faculty from the Department of Mining and Nuclear Engineering at Missouri S&T, instructors from industry currently employed on a flat rate to co-teach undergraduate mining department explosives classes and faculty from the Department of Civil Engineering at Missouri S&T and augmented as circumstances dictate by faculty from UMC, University of Kentucky and Texas Tech University. Preliminary exploratory communications have been made with the non-department faculty with agreement on principle but at this time it is not appropriate to go further until the MS is fully approved. These faculty are currently in reserve and will be called upon in the event of enrollment projections being exceeded and/or financial circumstances which delay the hiring of the third faculty member.

Professor
Paul Worsey, PhD, University of Newcastle upon Tyne (Missouri S&T)
Richard Bullock, D. Eng., Missouri School of Mines Emeritus (Missouri S&T)
Sam Kiger, PhD, University of Illinois at Urbana (University of Missouri Columbia)
Bruce Freeman, PhD, University of California Davis (Ktech, formerly at Texas A & M) ⁶
Associate Professor
Jason Baird, PhD, University of Missouri-Rolla (S&T) (Missouri S&T)
John Myers, PhD, Texas-Austin (Missouri S&T)
Assistant Professor
Braden Lusk, PhD, University of Missouri-Rolla (S&T) (University of Kentucky) ⁹
Brandon Weeks, PhD, University of Cambridge (Texas Tech) ⁹
Adjunct Industry Instructors Currently Teaching Courses at Missouri S&T

⁶ These have acknowledged interest in working with the program on an adjunct basis offering distance courses (from their current location), subject to S&T hiring policies & procedures.

Greg Shapiro, BS, University of Missouri-Columbia Steel Blasting
Matt Suttcliffe Premier Pyrotechnics
Marty Gillette Premier Pyrotechnics

We hope to broaden the scope of the program to involve professors from other disciplines on campus as the offering of courses expands. Some examples would be explosives chemistry, history of explosives, and shock wave physics in addition to cooperation with the civil engineering department on blast resistance.

- *Estimated percentage of credit hours that will be assigned to full-time faculty:* 80%.
- *Expectations for professional activities, special student contact, teaching/learning innovation.*
Faculty at Missouri S&T are expected to participate in teaching, research, service and outreach activities. Annual reviews, promotion and tenure, continuing membership on the graduate faculty and annual salary adjustments ensure the quality of faculty activities. The faculty of the explosives engineering program will be located in the Department of Mining and Nuclear Engineering. The name of the department will remain to reflect its undergraduate and highest degree (Ph.D.) offerings. The tenure and promotion of the explosives engineering faculty will continue to reside for the foreseeable future with the mining engineering program.

Enrollment Projections:

- *Student FTE majoring in program by the end of five years:* 20 (Form SE)
- *Percent of full-time and part-time enrollment by the end of five years:*
45% full-time students; 55% part-time students (rounded based on projections). It is expected that part-time students will be in the minority in the first couple of years but because part-time students take longer to graduate, their numbers will eventually exceed those of full-time students. The part-time students will be working professionals.

Student and Program Outcomes

- *Number of graduates per annum at five years after implementation:* 15
(10 full-time from year 4 (1+ years to graduate) and 5 part-time from year 2 (3+ years to graduate))
- *Special skills specific to the program:*
Understanding and application of the functioning of explosives and initiation systems. Understanding and application of explosion effects. Understanding and application of safety as applied to explosives in field use, testing and demonstration environments. Experience with the safe handling of energetic materials. Understanding of the application of explosives for fragmenting rock and other materials. Experimental design incorporating explosives. Expertise in focused professional areas such as demolition, blast resistance, rock breakage or weapons systems design, loading and production. Understanding of the challenges of using explosives and environmental impact.

Note: The graduate certificate has lower entrance requirements than a master's due to it being a non-degree program.

- *Proportion of students who will achieve licensing, certification, or registration:*
Graduates will become members of the International Society of Explosives Engineers and other professional organizations, as appropriate. At present there are no professional groups licensing graduates from explosives engineering programs. All licensing is at the state level, which comprises a) blaster's licensing (which may be at multiple levels depending on the state, b) display fireworks operator licensing and c) pyrotechnician and special effects licensing. It is anticipated that the majority of graduates will obtain licensing in at least one of these areas.
- *Performance on national and/or local assessments, e.g., percent of students scoring above the 50th percentile on normed tests:* The only applicable tests are state explosives licensing tests. More than 80% of the students are expected to score above the 50th percentile on these tests. (Based on past performance of students. Source: Dr. Worsey, state certification program examiner 1990-2008.)
- *Placement rates in related fields, in other fields, unemployed:*
There will continue to be growing opportunities for explosives engineers in the defense, mining and civil construction industries and in government institutions; therefore, we expect 100% of our graduates to be employed.
- *Transfer rates, continuous study:*
The program will not only attract students with previous degrees from Missouri S&T but also attract students from other technological programs throughout the United States. We already have five full-time students signed up for a traditional master's, three of which obtained a bachelor's at other institutions. These students are temporarily housed in the mining MS program. Our summer explosives camp has now been running since 2004 and indications show that many of the explosives campers who enroll at Missouri S&T for majors outside of mining also currently enroll in the explosives engineering minor. We anticipate that the majority of these students are potential candidates for the master's degree in explosives engineering. Unfortunately the Safe Explosives Act of 2002 (implemented in January, 2003) prohibits the participation of foreign nationals (non-residents). The major exceptions to this are those currently employed by Missouri S&T and by obtaining relief from the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE), which can take as long as 18 months. It is therefore anticipated that this graduate program will be unusually high in U.S. nationals.

Accreditation

- There is no accreditation for graduate programs in explosives engineering. It is expected that the students will have BS degrees from programs already accredited in science, engineering or technology.

Alumni and Employer Survey:

- *Expected satisfaction rates for alumni including timing and method of surveys:*
Missouri S&T will develop an assessment and evaluation plan for the curriculum in explosives engineering based on the ABET-accredited BS program in mining engineering. This will be developed after the MS is approved. We expect a 90% satisfaction rate of the alumni of the program. (Based on experience from our mining graduates.)
- *Expected satisfaction rates for employers including timing and method of surveys:*
Graduates will be tracked and Missouri S&T will develop an assessment and evaluation plan for gathering information from the employers of the graduates after the program has graduated at least 5 persons. We expect 90% satisfaction from the employers. (Based on experience from mining engineering program surveys.)

Form CC: CBHE CLARIFYING COMMENTS

Alignment with Institution Mission

The Missouri S&T mission statement is:

“Missouri University of Science and Technology integrates education and research to create and convey knowledge to solve problems for our State and the technological world”.⁷

A master’s program with research thesis fits this mission. Specifically the explosives master’s program emphasizes the integration of education and research by the graduate level education of students, their role in performing research for theses, and integration as a personnel resource for funded research after initial training. As the program advances, the number of faculty and graduate students will increase to complement the excellent facilities we have built and will significantly increase the level of scholarly activity. In addition, the uniqueness of the program allows the opportunity for meeting specific technological needs that the university does not currently address in any one program, as well as educating students and solving problems for the technological world in the areas of explosives, blasting, defense and homeland security.

The vision of the university is that Missouri University of Science and Technology will be recognized as one of the top five technological research universities in the nation. The **tradition**⁸ of this institution is based on mining (the Miners) and the first two programs on campus were mining and civil engineering, where 98% of civilian explosives are used. The expansion of the explosives engineering program, especially at the graduate level, will increase our visibility, which will afford increased research opportunities and lead to **excellence**. A healthy number of graduate students will allow us to expand our research load and the inclusion of graduate students in full-time employment in government institutions will afford new opportunities, including **interdisciplinary collaboration**. This program builds on the traditional history of the institution in an area with documented excellence. The suggested free electives will facilitate the opportunities for interdisciplinary collaboration.

The program also meets all four of the Strategic Objectives outlined in the FY 2008 – FY 2012 for the campus.

These are:

1. Enrich the Student Experience

The explosives engineering M.S. program covers both practical hands-on and theoretical aspects of explosives and their use, only available at S&T. The program not only provides a one of a kind degree but also a one of a kind experience.

⁷ Mission Statement Approved January 2008 Board of Curators’ Meeting.

⁸ Tradition, Interdisciplinary Collaboration and Excellence are 3 of the 4 values included in the Missouri S&T mission statement.

Explosives engineering interfaces with the entire student body at S&T. Explosives engineering students supervised by faculty, as one example, provide fireworks displays and special effects for events and celebrations on campus for the university, prospective students, student organizations and alumni. Such events have included night football games, athletic hall of fame inductions, opening week, Student Council block party, St. Pat's, St. Pat's coronation ceremony (indoors), the Indian Student Association Diwali celebration, homecoming and the list goes on. At present, the faculty and seniors (over 21) are stretched thin and cannot cover all requests. The increase in explosives graduate students will significantly increase the pool of license-eligible persons (due to age and maturity) and allow fuller support to the campus.

2. *Manage the Academic Portfolio and Increase Enrollment*

The Master's program fits this objective by increasing graduate enrollment. In addition, the existence of the degree will also help attract additional undergraduate students with an interest in explosives to the campus by cementing S&T as the premier institution in North American for explosives education and the publicity this will bring. It is a unique degree based on our history that represents a logical extension of our academic offerings.

3. *Expand and Elevate Research Performance and Reputation*

This objective is met by the increase in explosives engineering faculty and graduate students, which will push us over the critical threshold and lead to a strong increase in academic scholarship. As an example, current explosives engineering students are encouraged to publish their research, etc. even at the undergraduate level. The strong increase in the number of graduate students and additional faculty will substantially increase the number of publications and research projects.

4. *Identify Opportunities and Secure Resources from External Constituencies*

The mining engineering program has over the years been very successful in securing resources from external constituencies, being one of the leaders on campus (considering its size) in scholarships, grants, endowments and donations. In particular, we have strong alumni and industry support. We will establish an industry development board to assess, provide direction and input for the program and to help obtain further resources. The creation of the explosives engineering M.S. will position the university to secure additional resources in the explosives area. As an example, the Orica (explosives) Partnership for Mining Education approached Dr. Worsey in July to see how they can increase their involvement. This is a direct result of our visibility in explosives education and the explosives M.S. will only help cement this relationship. Currently virtually all explosives, drilling equipment, magazines, training aids and equipment used in classes have been provided by industry with negligible cost to the mining engineering department.

Student and Market Demand

Summary of Need for Program

The Master of Science degree in Explosives Engineering will fulfill the following needs:

- Satisfy current and prospective student interest in a graduate program in explosives engineering.
- Strengthen Missouri S&T's ability to recruit and retain graduate students with an interest in a technological field.
- Provide new opportunities for graduate research.
- Fulfill the market's need for explosives engineers with a specialization in one or more areas of technology.
- Strengthen Missouri S&T's ability to recruit and retain quality faculty in the explosives field and grow in this high profile subject area.
- Meet the needs of Department of Energy, Department of Homeland Security and Department Of Defense personnel, including those stationed at Fort Leonard Wood.

We currently have a Department of Energy (DOE) employee in our M.E. program who has requested the M.S. in Explosives Engineering program. He is doing research in explosive breaching for the protection of Department Of Energy assets. The Department Of Energy and Department Of Defense (DOD) research and development organizations want the highest qualified individuals and we have been told, for example by Picatinny Arsenal, that they would like to increase the credentials of their explosives engineering workforce. This led a few years back to a research contract for Dr. Baird to make a preliminary investigation for the set up of an energetic related PhD program. Unfortunately, the Iraq war preempted the funding for the performance of the project.

We have just received a \$100,000 ALERT (Awareness and Localization of Explosives-related Threats) education initiative grant funded by the Department of Homeland Security, the abstract of which is included here:

“BROADER IMPACT: The educational component of the ALERT Program will advance frontiers and knowledge in the homeland security front. Homeland security is an essential component of measures for securing the Homeland against explosives-related threats. This program will educate the next generation of leaders, scientists, engineers and policy makers, from K-12 through undergraduate to graduate levels, in effectively combating the dangers and effects of explosives-related threats. This program brings together scientists and engineers from the partner universities to contribute to a collaborative education venture. This collaborative partnership will provide students different classroom experience, to encounter different experts, and to gain knowledge in different dimension of explosives-related threats. Overall, the education initiative is a vehicle, along with the research initiative, for achieving the broader vision of the Center of Excellence in Explosives-Related Threats envisioned by the Department of Homeland Security.”

This \$100,000 grant indicates the importance of explosives engineering education. Missouri University of Science and Technology is part of a multi-university center for the ALERT program. S&T is recognized in this center primarily for its expertise in explosives education and its leadership in blast resistance research.

Mr. Steve Tupper, the S&T Fort Leonard Wood Liaison Officer has written the following comment concerning Fort Leonard Wood, the major army training base in Missouri and the home of the Army Engineer Center and Maneuver Support Center.

“Fort Leonard Wood is the training base for the Corps of Engineers whose missions include military demolitions. Each year 450 officers, all with fresh bachelor degrees from various ROTC programs and the Military Academy, are trained in basic explosives use, handling, safety, including hands-on application. Annually 25,000 newly enlisted soldiers are also trained on the same explosives basics, but since they have high-school degrees are not ready candidates for graduate studies. This training is done by a training cadre mix of officers and enlisted who are interested in more advanced explosive theory, practice and design. This last group is currently inquiring with Missouri S&T for in-depth training and certification making them a market-sector for the explosives engineering master program.”

Employment of Graduates

The major use of explosives is in the civilian sector, with over three megatons of explosives used in the United States each year (USGS Minerals Yearbook 2007). Of this, an estimated 85.5% is used in the mining industry (for extraction of metals, minerals, fuels and construction materials; for example Doe Run, the major mining company in Missouri, estimates that 10% of its current total mining costs come from drilling and blasting. An estimated 11.6% is used in the civil construction industry for road cuts, tunnels, structure basements and grading for large industrial, distribution and retail complexes. All other civilian uses of explosives combined account for 2.9%, including demolition, explosive welding, oil and gas exploration and production, etc. Another important segment is government, which includes the Department of Energy (DOE), the Department of Homeland Security (DHS), the Department of Defense (DOD) and the National Laboratories.

According to the New York Times⁹ and National Public Radio (NPR), the National Mining Association was quoted as saying, “The number of graduates of engineering schools with training in explosives cannot keep up with the demand in the mining industry, the leading employer of explosives engineers, and the current population of engineers in the field is aging toward retirement.” Five thousand mining engineers will be retiring in the next decade, and a substantial proportion of these are involved in the primary breakage of rock using blasting. In addition, the average age of technical personnel at Dyno (one of the country’s largest explosives manufacturers) is over 50. A similar situation exists in other explosives companies.¹⁰ With the Korean and Vietnam wars the defense industry was saturated with engineers, many of whom were in the same age group, the majority of which have now retired, leaving a substantial gap in

⁹ See Tuesday July 3, New York Times article in Appendix F.

¹⁰ Personal communications with explosives company representatives at all levels.

expertise, especially in the area of explosives. The Department of Mining and Nuclear Engineering at Missouri S&T, having recognized national expertise in the areas of explosives education, training and research is becoming increasingly approached by defense contractors, including Westinghouse, Alliant Technologies, etc. and DOD installations (such as the U.S. Navy's facility at China Lake, CA) and National Laboratories (such as the Idaho National Laboratory) for explosives engineers. Especially in the government sector advanced degrees are encouraged and there is significant interest in an MS in explosives engineering to complement our graduate minor in explosives engineering.

There is also a need for existing graduate engineers in industry and government to further their education and obtain specialized training in explosives engineering; this degree will provide a means of fulfilling that need. Missouri S&T has an excellent opportunity to fill key industry positions and dominate the field of explosives engineering, and thus increase the university's national standing in this area in industry and government. The Master of Science in Explosives Engineering is conceived as a specialist qualification for graduates holding accredited engineering, science and technology B.S. degrees, as is the practice in Europe and other parts of the world, paralleling the concept of an M.B.A.

The question has been asked "What does an M.S. provide that a certificate does not and how does this match need?" The answer is that an M.S. provides far more than a certificate,¹¹ including appeal to potential students and sound academic credentials. From personal discussions, capable graduate students that are interested in explosives engineering want to take the M.S. rather than a certificate or minor. They recognize the increased value of a specialized advanced degree in the workplace in addition to its desirability.

Societal Need

The use of explosives is extremely important to our current standard of living. Without explosives, raw materials would be very expensive to extract from the ground. In fact, one of the most famous people in history, Alfred Nobel (of Nobel Prize fame) was the inventor of dynamite, the modern blasting cap and a whole host of other explosives and propellants. Explosives are not only used to break rock so that it can be removed and easily processed for the extraction of metals (from iron to platinum) and minerals (from road salt to borax) but also in the removal of overburden in surface coal mining. Surface coal mining produces over 50% of the coal mined in the US, which in turn is responsible for the production of one third of our power generation. Explosives touch almost every aspect of our modern lives. There is an adage in mining that if it can't be grown, it has to be mined. As far as explosives are concerned, if the rock is tough, then generally, explosives have to be used. The abundance of cheap raw materials and energy in modern civilization is attributed to high explosives and Alfred Nobel.

In civilian excavation and construction, explosives are extremely important for rock breakage. The majority of rock cannot be economically ripped using mechanical excavators, whilst

¹¹ A certificate is not tied to a degree like a minor and is principally designed for those persons who are not able to obtain a degree due to academic circumstances (inability to meet graduate school entrance requirements for an MS or PhD) or other considerations, such as career commitments, financial and family considerations, etc.

explosives and blasting provide an economic solution, especially for the removal of large volumes of rock. Just in the state of Missouri, you only have to drive down the highways and marvel at some of the rock cuts, not only along I-44 and other highways, but also at the scale at which rock excavation has been undertaken in the Branson area, for example. Leveling and grading is extremely important for the construction of large industrial and retail facilities, not only for the efficient use of machinery but also for the Americans with Disabilities Act. An example of the importance of blasting is the Wal-Mart distribution center located in nearby St. James, one of the largest such facilities in the U.S. Although being sited on what appears to be a flat field it actually required over 50 thousand cubic yards of rock excavation by blasting so that the facility floor could be level.

An important item in maintaining the American way of life is the ability to defend the country, and explosives are an important part of this. We have placed a number of our graduates with qualifications in explosives engineering with governmental agencies and contractors in the defense industry, including China Lake and Applied Research Associates, Inc. Although the vast majority of these graduates have been BS mining majors, the mix of academic BS majors is changing and we anticipate because of this, placement in government agency positions to increase. There have been several recent inquiries for graduates in the explosives area and requests for students with master's in the explosives area. Offering a master's in explosives engineering will allow valuable training for government and defense contractor personnel and provide a mechanism for personal advancement.

The terrorist attacks on September 11, 2001 brought home to American soil the threat of international terrorism. Before this terrorist act in the US, there had been numerous attacks on U.S. installations and personnel throughout the world using explosives. But now there is an increased need for research in combating explosive terrorism including blast resistance, detection and defeat mechanisms for terrorist explosive devices including improvised explosive devices (IEDs). A substantial amount of work has been started for the protection of critical infrastructure by the Idaho National Laboratory, including highly classified work. Several research contracts are in place at Missouri S&T to address portions of this need. Currently, there is a severe lack of personnel with adequate credentials and training in the field of explosives engineering to meet critical needs, as explained in the next section. Currently, the certificate only provides basic level training with 12 credit hours of study. Although the certificate provides a good foundation, it does not provide anywhere near a comprehensive mastery of the subject. The master's degree proposed provides in-depth training with a minimum of 24 credit hours of class work and six hours of research.

Efficient Use of Resources

Missouri S&T is particularly well suited and equipped to support a Master of Science degree program in explosives engineering to be offered by the Department of Mining and Nuclear Engineering. Key factors include the strength of the Department of Mining and Nuclear Engineering, the nature of Missouri S&T as a technological university and opportunities for research, internships, and co-ops.

Department of Mining and Nuclear Engineering.

The department has several years of experience developing and teaching courses in explosives engineering as part of its minor in explosives engineering. It has capitalized on this long history of teaching and research in the explosives engineering field in recent years, increasing its course offerings and rebuilding its faculty in this area such that a sustainable master's is now possible. Because Missouri S&T is a research university, the faculty have a strong tradition of research, teaching and service.

Missouri S&T as Missouri's Technological University

Missouri S&T's strong reputation as the state's technological university and as one of the top providers of M.S. and Ph.D. graduates in engineering and science in the country, along with its reputation and tradition in this field, make it the logical home for an explosives engineering program. In calendar year 2008, eight separate explosives engineering-related courses (totaling 24 credit hours) were taught (excluding 390 and 490 research courses and 300 and 400 special problems courses), thirteen \$1,000 scholarships were given by the International Society of Explosives Engineers to Missouri S&T students and, with the assistance of the Chancellor, the full-time explosives faculty increased to two. In conjunction with industry instructors we have now reached a sustainable level where master's students can obtain a degree in explosives engineering with a degree of flexibility of course selection within classes offered at Missouri S&T.

Benefits of Collaboration

The MS degree in explosives engineering does not involve collaboration with any external institution or organization, except for the collaboration of Profs. Lusk and Weeks at the University of Kentucky and Texas Tech University, respectively. However, the current Master's Degree rules allow for a maximum of nine hours of course work to be transferred from universities outside the University of Missouri, which allows for future cooperation with universities offering additional courses to those offered by Missouri S&T, which would be advantageous to a master's candidate. There is the possibility of cooperation with the University of Missouri Columbia on a course or two on the blast resistance of structures and we will be looking at cooperation with other institutions (such as Texas Tech and the University of Kentucky) and former academics now in industry for courses in specialized explosives chemistry and other areas not covered within our course offerings.

The program we are proposing is unique. It is not duplicated on the campus, in the system, the state or anywhere in the Americas. It may also be unique in the world. The only other related degree that comes anywhere close at the moment is a Master of Science in Engineering Mechanics with Specialization in Explosives Engineering offered by New Mexico Tech. However, the requirements for this specialization are less than the requirements for the current graduate minor in explosives engineering at Missouri S&T and the specialization is more along the lines of the Missouri S&T undergraduate emphasis in explosives engineering. New Mexico Tech is not seen as a competitor. The degree is in engineering mechanics and the program is solely theoretically based, and the program restricts the handling of explosives to persons with military EOD certificates. At S&T, in comparison, hands-on practical explosives handling by on-site students is mandatory. Two examples of why New Mexico Tech is not a significant competitor are that one of their graduate students chose to send his son to our summer explosives

camp over their version and two students who came to S&T in the summer of 2007 from NMT because they were not allowed to handle explosives at the NMT camp.

In contrast, our students have handled explosives for at least 90 years, since the inception of the school experimental mine in 1918¹².

Form CP: CRITERIA BY THE PRESIDENT

Implementation of the New Program

Implementation of the M.S. will not negatively affect existing programs in the department of mining and nuclear engineering or other programs at the university. It is expected that implementation of the M.S. will increase graduate enrollment from the B.S. level of the mining department, as shown in Appendix B. Furthermore the MS will complement the current M.S. and M.E. programs in mining engineering by enrolling additional graduate students who would otherwise go to industry. It is also anticipated that approximately 25% of these students will continue on to be new P.hD. admits in mining engineering or other departments on campus. This program is part of Objective 1.3 contained in the Mining Engineering Program Strategic Plan 2006-2010.

Market Analysis

According to the current industry job market evaluation there is a critical need for qualified graduates with advanced explosives training. Such evidence is based on industry and organizational support outlined in Appendix G, in which professionals are seeking highly trained graduates in explosives and explosives engineering to meet the growing vacancies due to retirement. As stated by Bruce Neil et al. of the Doe Run Company, "... the combined need for people with the best credentials, training, and experience in the form of advanced explosives engineering degrees would be at least 10 per year."

According to a recent poll of approximately 200 S&T mining engineering students, nearly 20% expressed a definite interest in the M.S. in explosives engineering program. While this data is based on an internal study there is additional external interest with three outside students already enrolled waiting for the M.S. program to be approved. Due to snowballing interest it is now anticipated that enrollment in the M.S. may have to be limited soon after implementation. This interest is outlined in Appendix B and is based on practical experience with the explosives minor and ME in mining engineering. The department already has experienced substantial growth and been successful in the implementation of these programs. Both have shown exponential growth, as shown in Appendix A. The M.E. program started in 2001, the first graduate was in 2004 and there are now 13 graduates.

Business Plan (Available Upon Request)

Action Plan for Program Delivery

Nearly all of the courses required for the program are in place; we already offer nine classes in explosives engineering, which are enough classes to operate the program. In addition, the physical infrastructure is also in place. The explosives engineering M.S. program as outlined in the administrative structure on page 15 will be an integral part of the department of mining and nuclear engineering at S&T, and the students will be counted as mining engineering program graduate students. The explosive engineering M.S. will join the other four existing offerings in the graduate mining engineering program, Ph.D. in mining engineering, M.S. in mining engineering, distance M.E. in mining engineering and graduate explosives engineering minor. The existing reporting structure for explosives engineering will remain in place. Explosives Engineering is headed up by Dr. Paul Worsey, Professor of Mining Engineering and Director of Explosive Curricula who currently reports directly to the department chair, Dr. Frimpong. The program director's home academic unit already provides support for the program infrastructure, such as budget management, human resource services for program staff and office space for the director, faculty, staff and graduate students. A development board will be created paralleling that of the mining department to provide industry and government input. The development board will also assist the explosives engineering program in obtaining industry support. The classes in the program are already taught by existing mining faculty (Drs. Worsey and Baird), Quenon Chair Professor Emeritus Dr. Bullock and with assistance from adjunct instructors from industry. As the offering of courses increases we will draw additional faculty from other units on campus. Cooperation with faculty at other universities for specialized topics and additional adjunct instructors from industry is also a possibility.

Graduate Employment

Statistics on job placement for B.S. degree individuals in mining engineering and graduates with a minor in explosives engineering in conjunction with letters of support from industry show that the graduates will be highly successful in securing employment. To facilitate successful employment matches with industry, government and the military, the program director and faculty will meet with employers on a regular basis. This will occur through a development board. Discussions will focus on the program meeting their current and future workforce needs. These meetings will ensure that the program offerings are updated on a regular basis and address their present needs. The development board will also help market the program and its graduates to current and potential employers. In addition to the department, S&T also has the Career Opportunities Center (COC) and students will be referred to their resources if and when needed. The COC not only interfaces with employers but provides career and interview counseling services to hone students' interview skills and success in job application.

Evaluation

The effectiveness of the explosives engineering M.S. will be measured against several criteria. There will be three categories of evaluation – financial, graduation metrics and program effectiveness.

The financial evaluation of the program will be based on enrollment, number of classes completed and incurred costs. Enrollment statistics and costs versus targets will be assessed at the end of each year and the data used for program development purposes.

It is important that the program is financially sound and producing a sufficient number of master's graduates. The annual number of graduates as a percentage of the matriculating students for each year will be tracked for both traditional students and non-traditional distance students. This is to make sure that the program is on track and retention targets are met. In addition, the placement rate of graduates will be tracked. It is expected that greater than 90% of graduates will find work within three months of graduation. This evaluation will begin as soon as we start to graduate students.

Program effectiveness will be measured using several criteria, including:

- Development board review of coursework and the overall program
- Alumni surveys used as a qualified measure of graduate satisfaction of the program, with strengths and weaknesses to be identified
- Employer surveys of satisfaction with graduates' skills and abilities to work in explosives engineering and strengths and weaknesses of their knowledge base and skills¹³

This evaluation of program effectiveness will be made at the end of each semester for the first and second years, annually for the next three years and biennially thereafter.

SECURITY CONSIDERATIONS

The importance of explosives education is vital to civilian industry, government and the defense industry, yet explosives knowledge, like that from the majority of other technical disciplines, can also be used against society. Since the terrorist attacks on September 11, 2001, U.S. academic institutions have come under increasing scrutiny. The Safe Explosives Act of 2002 expanded the number of categories of persons banned from possessing explosives to include non-U.S. residents, those with dishonorable discharges from the military and those who have renounced their citizenship. This list is in addition to felons, fugitives from justice and those who have been declared mentally defective. Not only is it illegal for these groups of people to have access to explosives but it is illegal for institutions to provide such persons with explosives without first obtaining a waiver from the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives.

The Safe Explosives Act requires background checks for users of explosives and so each prospective student will require a completed background check. Proof of an existing background check, such as holding a state blaster's license or CDL with Hazmat endorsement, being a current member of law enforcement, military, appropriate government agency or national lab or holding a security clearance will be accepted. A prospective student without proof of an existing background check will have to pay for and undergo a highway patrol background check. The check needs to be completed before acceptance into the program.

¹³ Both alumni and employer surveys are already used in the mining engineering program and will serve as a template.

Dr. Henry Wiebe, Dean of Extended Learning, strongly supports the teaching of explosives courses by distance to bona fide individuals and organizations, realizing that a degree of determination of the authenticity of these groups is necessary. Distance education is becoming increasingly important, especially to degreed professionals already entrenched in the work environment who are unable, because of work or family commitments and/or financial consequences, to pursue conventional higher education in specialist fields. He further supports the extension of the MS in explosives engineering to S&T's distance education program. Note that in order to actually handle explosives a student would need to study on campus. In addition, distance students would be vetted so that not just anyone would be enrolled in the program; they would have to be admitted by the registrar first.

References

Apodaca, L.E. "Explosives" USGS 2007 Minerals Yearbook, U.S. Department of the Interior, September 2008, pp 23.1-23.5.

Bureau of Labor Statistics "Mining and geological engineers, including mining safety engineers" National Employment Matrix 17-2151, U.S. Department of Labor, 2006.

Bureau of Labor Statistics "Explosives worker, ordnance handling experts, and blasters" National Employment Matrix 47-5031, U.S. Department of Labor, 2006.

Guberman, D.E. "Lead" USGS 2007 Minerals Yearbook, U.S. Department of the Interior, February 2009, pp 42.1-42.6.

International Society of Explosives Engineers Personal Communication from the Assistant to the Executive Director, August 2009

Morris, F. "At Camp, Teens Blow Stuff Up, As They're Told" NPR, June 20, 2007
<http://www.npr.org/templates/story/story.php?storyId=11226636>.

Schwartz, J. "A Summer Camp Where Fireworks Are the Point" New York Times Science Times, pp F1 and F4.

Willett, J.C. "Stone, Crushed" USGS 2007 Minerals Yearbook, U.S. Department of the Interior, January 2009, pp 71.1-71.8.